ON GUNSHOT INJURIES PRODUCED BY THE NEW PROJECTILE OF SMALL CALIBER.

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ON GUNSHOT INJURIES PRODUCED BY THE NEW PROJECTILE OF SMALL CALIBER.*

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In looking over the literature of the experiments made by military surgeons with the new rifle and projectile of reduced caliber, it occurred to me that a short account of the results, so far obtained, might not only prove interesting to you, but would also tend to make you all the better appreciate the necessity for the instruction in the principles of "First Aid to the Injured," which you are shortly to receive, besides having a direct bearing on your profession.

It is a fact well known to you that the nature and character of any injury to the human body must depend to a large extent upon the nature and character of the agent that produces it—be this accidentally or intentionally.

The more common and well-known instruments by means of which the great majority of wounds and other injuries are produced in the ordinary walks of life, are generally so well known and so simple, that an experimental study of their effects on the human body may well be neglected. Besides, the conditions under which injuries in every-day life occur are so manifold, that it would indeed be a difficult task to devise plans of experimentation in order to systematically study them all before they occurred.

It is, however, very different with cases of injury that are produced by firearms. Here we have at once certain uniform conditions that may very advantageously be studied beforehand, and a

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great deal of practical experience and knowledge can be gained by experiments on dead human bodies, as well as on living animals, in regard to the nature of the injuries produced by them.

Different fire-arms produce different injuries and, consequently, any change in the one must likewise be followed by changes in the other, and, since the treatment of all injuries again depends upon the nature of the injury itself, it also must be modified to suit the new conditions of things, whatever they may be.

The most important change in the new small firearm that has been made and that interests us in this connection, undoubtedly, consists in the reduction of the caliber of the gun. The improvement, in other words, has gone on in the same direction in which it started some fifty years ago, namely, in the doing away with the round ball and the smooth-bore barrel and the substitution of a pointed projectile within a rifled barrel.

Thus the old Minié arm had a caliber of 18 mm.; then came the Prussian needle-gun with a caliber of 14 mm., which proved its superiority in the war of 1866 against Austria; next came the chassepot and Mauser guns with a caliber of 11 mm., and now the present small-arm with a caliber of from 7.5 to 8 mm. And no sooner had the caliber of the 7.5 mm. been more generally adopted, than the Italian and Roumanian armies were fitted out with rifles of the caliber of 6.5 mm., and this tendency towards reduction has by no means come to an end yet and may reach 5 mm. before very long.

The great superiority of the French chassepot over the Prussian needle-gun was never more plainly shown than at the battle of Gravelotte, in which alone 19,863 Prussian soldiers were wounded, owing to the murderous effect of the chassepot.

Along with the reduction of the caliber of the projectile a reduction in weight has come about from 50 to 15 grams, and a still greater reduction is expected.

The result of a reduction in caliber means, as you may know, increased velocity for the projectile, increased distance and a surer aim. In this manner a small-arm has been produced that will impart a velocity of from 4–600 meters per second to the projectile and send it a distance of from 4–5000 meters; the rotatory velocity has been calculated to be from 800–2500 rotations per second. Habart calculates the velocity of the Männlicher projectile, model

1888, to be 620 meters per second, and the number of its rotations at 2480, which would mean four rotations to the meter, or one rotation to 0.25 meter.

It is principally due to Professor Hebler, a German artillery scientist, who published a pamphlet in 1882; the results of his studies demonstrate most conclusively the advantages to be gained by a reduction in caliber and the use of hard mantles for the projectiles.

The importance of this publication is most evident when we realize that the change therein recommended was at once adopted and is now an accomplished fact with all modern armies. It may perhaps be interesting, in this connection, to note how nearly Hebler was anticipated in his discovery by the English army-surgeon Longmore (quoted by La Garde), who, in 1870, expressed himself as follows: "If bullets of steel or any similar hard and coherent metal should ever be found capable of being economically employed in firearms, many of the ordinary features in gunshot wounds, as they at present exist, will be materially changed. In proportion as the hardness and cohesive force of the metals increase, the greater also will be the ease with which the brass plates and other accoutrements, the strong bones of the extremities, the vault of the cranium and any resisting structures will be perforated by it. Again, we shall have bullets which will not become softened at ordinary increases of temperature, broken and dispersed in fragments, subject to loss of substance, and capable of undergoing the various alterations in form which leaden bullets are apt to assume on coming in collision with certain external objects and hard parts of the body."

Indeed, the general adoption of this new small-arm is in no small measure due to the results obtained by experiments made on dead human bodies and living animals by military surgeons.

Thus we find military surgeons busy experimenting with this new instrument of destruction as early as 1886.

In Germany it was Busch and Reger who were among the first to call attention to the difference in the destructive effects produced between the old leaden bullets of large caliber and the new hard bullet of small caliber. From Russia the subject received valuable experimental contributions through Professors Morowsow, Tauber and Pawlow. In France, Delorme, Chavasse, Chauvel and Nimier did excellent work in their experiments with the Lebel rifle on dead human bodies. Bruns, of Germany, and Habart, in Austria, came out with the results of experiments made with the Mauser and Männlicher guns respectively. Quite recently Smith, of England, published some very painstaking experiments with the Lee-Metford bullet on the bones of horses, and the United States are most creditably represented in this matter by a most valuable experimental contribution made by Captain L. A. La Garde, of the Army, which is published in the last report of the Surgeon-General to the Secretary of War.

Inasmuch as the effect of projectiles upon the human body must be more or less complicated, owing to the composition of that body, it is the usual thing to begin the study of any new projectile by first ascertaining its effect on simpler materials, such as wood, iron and water, the resistance of which is tolerably uniform.

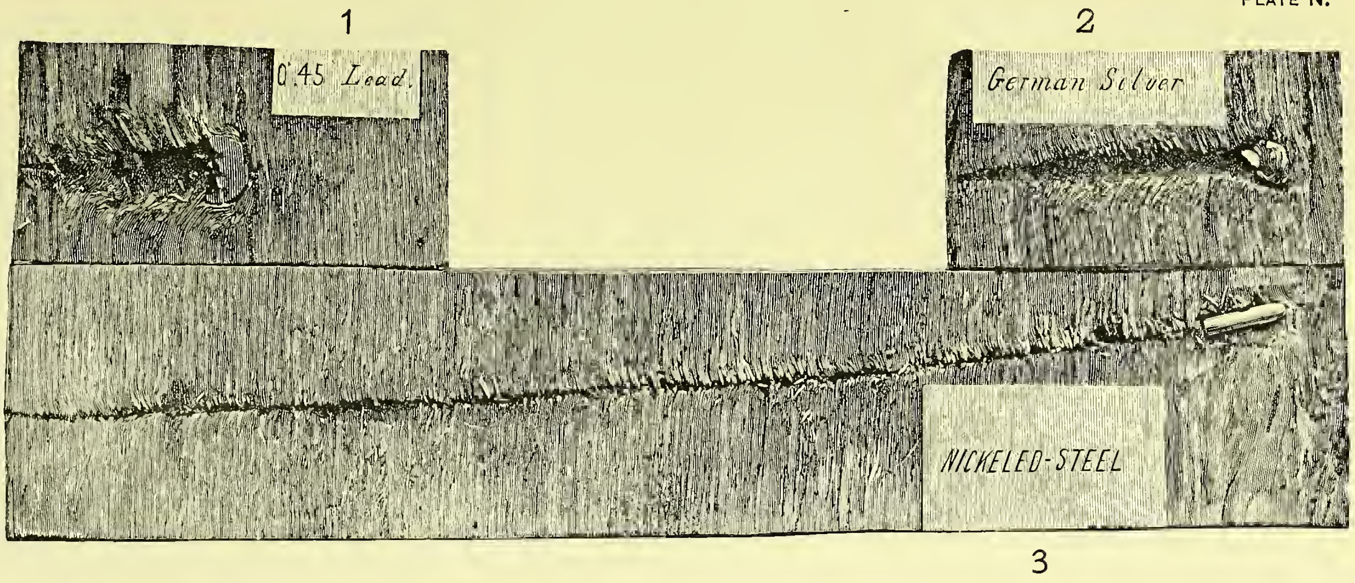
Thus, one of the first results obtained with the new rifle on wood was that its penetrative effect was from 5 to 6 times greater than that of the old arm.

La Garde found the maximum penetration in solid blocks of oak, not thoroughly seasoned, fired across the grain, at 3 feet from the muzzle, with a striking velocity of 2000 foot seconds, to be as follows :

230-grain	copper-covered	bullet	penetrated	4	inches.
220	" G. S.	"	"	5.3	"
220	" cupro-nickeled steel	"	"	19.5	"

If it is assumed that a projectile capable of penetrating a wood-board of one inch in thickness would still suffice to put a man out of combat, then this new arm is capable of doing double that amount of work at 1800 meters distance, and when, furthermore, it was likewise ascertained that the new projectile penetrates an iron plate 12 mm. in thickness near to, and one 2 mm. in thickness at a distance of 1000 meters, it becomes pretty evident that the steel-helmet and cuirass have at once become a useless burden and rather antiquated.

In some German experiments, made with the new bullet under water, in which the pressure was ascertained by a manometer, it was found that this pressure was much greater than had been anticipated, amounting to as much as 15 atmospheres. The resistance offered by water is very great, and a projectile that will cover



Shows the penetration in hard oak, against the grain, 3 feet from the muzzle, of the following projectiles:

1. .''45 caliber leaden projectile, 500 grains; I. V., 1300 f. s. .... 3.2''
2. .''30 caliber German silver jacketed projectile, weight, 220 grains; I. V., 2000 f. s. .... 5.3''
3. .''30 caliber nickel-steel jacketed projectile, weight, 220 grains; I. V., 2000 f. s. .... 19.5''

The latter was not deformed.

a distance of 4000 meters in the air, will advance but two or three meters under water. But this increased pressure is, in part at least, overcome by the shape given to the new projectile, and while the form of the old leaden bullet was much changed, that of the new bullet remains unaltered.

The chemical composition of the mantle of the new projectile, as shown in the above-mentioned experiments of La Garde, seems to be the at present more important consideration in its penetrative effect, the softer compositions causing deformation, their penetrative effects are greatly lessened, thus changing the entire character of the arm.

The copper- and German silver-covered projectiles were very much deformed in the experiments of La Garde, whilst the cupro-nickeled steel-covered projectile retained its shape unaltered, and since the velocity of the projectiles and the hardness of the oak blocks were constants in the experiments, the difference in penetration can only be due to the deformation of the bullets. These results would make it pretty certain that the cupro-nickeled jacket has more resistance than any of the others, and its penetrative effect must, consequently, be greatest.

Of the European armies which are supplied with this cupro-nickeled-bronze bullet, there are the German, Belgian and the Turkish. The Russian and French armies are supplied with projectiles of hard lead covered with Melchior-metal, and the Austrian army is supplied with projectiles covered by nickel-steel.

Thus, it will be easy to understand how many are the peculiarities which the new arm presents when studied in detail, and how manifold must be their influence on the injuries which they produce, even when regarded from the point of view of their penetrative effects alone.

But the new arm possesses also an increased explosive effect, which likewise deserves attention because its influence on the human body, and the nature and character of the injuries inflicted thereby, must be very marked. What do we mean by explosive effect? We have already mentioned that the pressure caused by the new arm under water was equal to about 15 atmospheres, and to this hydraulic pressure must be attributed to a large extent the explosive effect which the new arm produces.—(*Hebler*).

Some of the experiments of La Garde may perhaps better than anything else illustrate the probable nature of this effect.

LaGarde employed (1) empty powder cans, firing into them at various distances; he found that in the empty cans the orifices of entrance and of exit were proportional to the size of the projectile employed. (2) He next used powder cans used with wet saw-dust; in these the orifice of entrance presented no special features, while the orifice of exit was marked by a bursting forth of the tin, and a loss of the contents of the box. The cans, he says, had expanded as if driven apart by some internal force which had been exerted in all directions. (3) He then took powder-cans filled with water; in this case the results obtained were similar to those with wet saw-dust, only much more extensive, and about equal for the two projectiles which were employed.

The term "explosive effect," then, undoubtedly, as used in connection with injuries, owes its origin to the fact that the conditions which are found are similar to those produced by an explosive bullet.

In his further studies of the explosive effects produced by the Springfield and the experimental Springfield rifles respectively, La Garde found that no difference existed in the injuries which they both produced up to a distance of 200 yards, but that, at this distance, the old rifle ceased to produce explosive effects while the new Springfield rifle continued to do so up to a distance of 350 yards.

I will, for the sake of giving a general sketch of a wound showing explosive effects, quote from La Garde's report, who says:— "When we say that a wound shows explosive effects we mean that it appears as though it has been caused by an explosive bullet. There are no special features, as a rule, to describe about the wound of entrance (powder-can) except the appearance at times of bony sand in the tract leading to a fractured bone. When a resistant bone has been hit, the foyer of fracture will show great loss of substance, the bone will have been very finely comminuted, the pulverized bone will have been driven, not only in the direction in which the projectile was traveling, but in all directions, and the pulpification of the soft part will not only be limited to the track of the bullet, but the utter destruction is noticed to extend some distance into the surrounding tissues. The wound of exit appears like a bursting forth of the skin: the track leading to the bone is conical in shape, the base of the cone corresponding to the wound of exit in the skin, and the apex to the seat of fracture."

In short, then, the term "explosive effect" is applied whenever the injury produced by a certain projectile is found to be entirely out of proportion to the size of the bullet itself, that is, when the wound caused by it is much more extensive than would be necessary to have it admit the simple and easy passage of it, and whenever the surrounding tissues are either pulverized or pulped for a distance around the track of the bullet.

Now, although it is true that the amount of explosive effect produced depends upon the velocity of the projectile on the one hand, and the resistance offered by the tissues struck, it has been produced not only in bones, but also in the soft tissues such as muscles and the internal viscera as the heart, liver, spleen, kidneys, stomach, intestine and bladder. In other words, the amount of resistance offered to the projectile by the different tissues of the body has, as experiments would seem clearly to demonstrate, not as much influence on the results as we would be inclined, at first thought, to attribute to it, and the velocity of the projectile appears to have the lion's share in the production of the explosive effects. Habart also has shown that the hydraulic pressure theory is not tenable, neither is the theory of Melsen, who thought that a column of air was traveling in front of the projectile and which reached the body before the projectile did, and that to this was to be attributed the apparent explosive effect. In the case of the projectile entering the stomach, intestine or bladder, the amount of injury done to these organs seems to depend greatly on whether they are empty or whether they contain their normal ingesta. The damage done is much greater when they are full. In apparent contradiction of this, Habart exhibited a human heart, the result of a suicide, that had been perforated at 10 paces with a Männlicher projectile but which showed no explosive effect but merely a simple perforation; as he, however, suggests himself, the ball must have entered the heart in a moment of systolic contraction, when, as you know, it is practically a solid piece of muscle without fluid contents.

Let us now, after these considerations, look at this new arm in its relation to the injuries which it produces on the human body, and let us examine some of the results of the experiments that have so far been made in this direction.

One of the first and principal points that had to be ascertained in the case of every gunshot wound before the introduction of the new arm, was, as to whether the margins of the wound were contused and lacerated or not. In the former case we naturally expected that the healing process would be long and tedious; in the latter case this would not be the case, but the margins might be brought together by sutures and immediate healing take place.

Now, the new projectile differs from the old in that the lead which forms the body of it and gives it the necessary weight, is completely surrounded by a hard mantle, particularly so about its point. The former leaden bullet meeting with resistance, was at once considerably changed in shape, the small amount of heat produced in the collision melting it and, consequently, the resulting surface of contact became, comparatively speaking, large.

This is no longer the case with the new bullet, and while, perhaps, under certain circumstances, a slight dulling at the point takes place, this will hardly ever amount to enough to cause a material enlargement in the points of contact.

It has, it is true, been found, when the new projectile struck very hard substances, such as quartz, that the steel mantle became loosened and was stripped off, giving rise to an altered shape of the bullet, but even then this alteration did not assume the grotesque shape that the old bullet often did and is of rare occurrence.

Experience in the field had over and over shown that the amount of contusion and laceration were always greater, the greater the amount of contact surface of the injuring object, and experiments had demonstrated that the contused margins came not only from too great pressure upon the surface of the skin, killing every particle of it instantly, but that it was also due to overstretching which more especially resulted in extensive lacerations.

This essential character of gunshot wounds has been greatly changed through the introduction of the new gun. The experiments so far made give the resulting wounds as smaller and with much less contused margins than those produced by the old bullets. The theoretical supposition, that, owing to the small caliber and its increased velocity we would be led to expect small wounds with sharply cut edges, was borne out by practical experimentation. The amount of substance that is removed by the new bullet resembles in shape a cylindrical piece, although perhaps ground into atoms and not retaining the shape of the opening which its removal by the bullet leaves in the injured part.

In wounds confined to the soft parts alone, no very great difference in extent of injury between the wound of exit and that of entrance will generally exist; at most, we may find a more serious condition about the wound of exit or the point at which the ball leaves the injured member. Healing then, in wounds of the soft part alone, will, in the majority of cases at least, proceed a good deal after the manner in which this process is accomplished in wounds made by the knife, providing that antiseptic precautions are used.

There is, however, a new side in the character of the wounds thus produced which requires our consideration, and although the cleanness of the cut produced by the new bullet has, as we have seen, its advantages, so far as healing is concerned, it also has certain dangers not to be lost sight of.

The greater, for instance, the amount of contusion and laceration in the wounded part, the less may we also expect the hemorrhage to be, for nothing favors the arrest of hemorrhage so much, temporarily at least, as does the stretching and lacerating of arteries.

The new projectile, cutting like a knife, or, worse still, after the manner of a scoop, produces neither contusion nor laceration and, consequently, nothing to arrest the hemorrhage occasioned by the injury, in case an artery of some size has been cut. The direct consequence of this will be a much greater number of deaths from hemorrhage in the field than has been the case in previous wars.

Besides, formerly, instances occurred quite frequently in which large arteries lying right in the very track of a bullet had not been injured, the bluntness of the contact surface having pressed them aside and thus the bullet had avoided them. No such results are expected to occur in the future. The new bullet will, in its rapid flight, scoop out a piece of the wall of an artery and leave it gaping. This has already been proven, not only by experiment but by actual experience in the field. In the late civil war in Chile, in which a certain number of the congressional troops were armed with the Männlicher rifle, the number of deaths from this cause, according to Stitt and Videro, was calculated to have been about four times as great as that with the old bullet. This fact has been furthermore confirmed in numerous attempts at repressing street-riots, and also during the civil war in the Argentine Republic, where the mortality from this cause is said to have reached the highest rate. Kipper relates the following interesting case: A recruit, having his rifle at "order arms" accidently fired off the charge; the ball entered his neck cutting out a piece of the external carotid artery as if by a scoop and, consequently, death from hemorrhage was almost instantaneous.

The nerves seem to be the only structures, according to some experimenters, that escape injury sometimes by being apparently pushed aside.

Shots through the lungs with the new projectile seem rather more favorable than with the old bullet, in spite of the track being from three to four times larger in diameter than that of the bullet. Vessels may show clean perforations at great distances. Thus it has been found that, at 2000 meters distance, a shot received in the neck cut the internal jugular, wounded the sympathetic nerve and caused a fracture of the spinous and articular processes of one of the cervical vertebræ.

A projectile fired off at a distance of 600 meters and entering the chest perforated the margin of the sternum, traversed the lung, went through the body of the fourth dorsal vertebra and carried away its transverse and spinous processes, besides also fracturing the lamina of the fifth vertebra.

When a shot enters the abdomen, the intestinal canal is generally found perforated in several places. The openings have the diameter of the bullet when the canal was empty at the time, but more extensive lacerations are the consequence of the injury in case the canal is distended by its normal contents.

The openings made in the fasciæ covering the larger muscles are usually found to be smaller in diameter than those made through the skin, while the serous membranes, as the pleura or the peritoneum, show wider breeches of continuity.

The most characteristic injuries and the most extensively studied are undoubtedly those done to the bones.

Formerly, most any bone of any thickness seemed sufficient to arrest the old bullet; it was often found, very much deformed, imbedded in the substance of an irregular bone, having produced extensive and wide-spread splintering, thereby causing a rather complicated condition of the wound and greatly impairing the normal process of healing of the soft parts.

PLATE II.

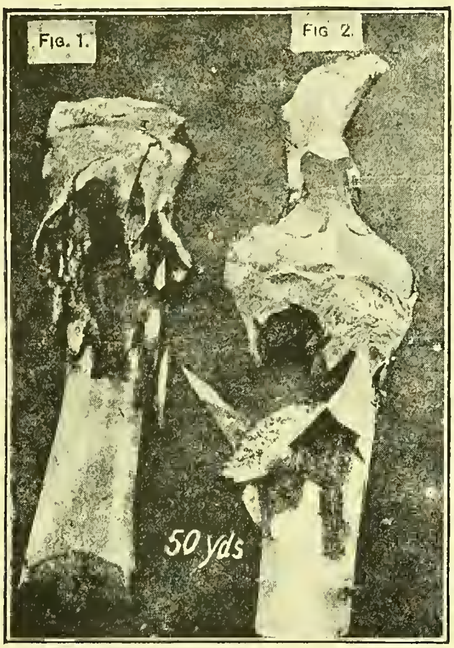


PHOTO. A.

PHOTO. B.

Instances have occurred even with the old projectile in which it had gone clean through the knee-joint without wounding either bone, something which is not impossible at any rate when the leg is in semi-flexion and the ball enters from behind. But such instances as these are, of course, still more likely to occur in the future with the new projectile, which perforates several of the strongest bones in succession, rarely, if ever, remaining imbedded. Trees of great thickness and brick walls are no longer a protection against bullets. The increased velocity of the modern projectile will no longer allow of the easy and formerly often experienced deviation in the course of the bullet, as experiments on human cadavers have abundantly demonstrated.

But the greatest difference is here noticed with regard to the distance from the muzzle at which the projectile strikes the bone and also as to whether it strikes the harder portions, such as are found in the shafts of long bones, or the softer and more spongy portions of the bones, that are found in the articular extremities. It is owing to this difference of effect from different distances that the range of fire within which bones may be struck in an actual campaign has been divided into different zones. Although we still find slight differences of opinion to exist between the different experimenters with regard to the extent of these zones and the character of the injuries produced within each, yet the fact that each zone presents its characteristic injuries to bones cannot be doubted for an instant. The causes for this difference of opinion seem to lie, on the one hand, in the difference in the projectiles used by the various experimenters leading to varying results, and, on the other, in the different conceptions that they have of what is termed "explosive effect."

It seems a mistake that, because of an artificial division of the range of fire being made, the injuries must always be necessarily of the character described for the majority of them; exceptions must occur, and occur frequently.

Habart, who is undoubtedly one of the most clear-headed experimenters in this direction, and whose authority therefore deserves the greatest possible consideration, distinguishes four zones, viz: 1. The zone of explosive effect which lies within 500 metres; 2. The zone of *mean* distance which is between 500 and 1200 metres; 3. The zone of *long* distance between 1200 and 2000 metres, and 4. The artillery-zone lying anywhere beyond 2000 metres.

As a general rule, we would be led to expect to find injuries showing explosive effects within the limits of the first zone in accordance with the results obtained by most of the experimenters, fractures of bones with loss of substance and most extensive splintering. Within the second and third zones purely perforative effects would be the rule, the extent of the fissures and the number and size of the splinters varying with the distance. While beyond 2000 metres, or within the limits of the artillery-zone, we again find more serious injuries to the bones recurring.

But Habart himself mentions a case in which he obtained a purely penetrative effect within a hundred paces, and also other instances in which explosive effects were found produced at distances of 1500 to 2000 metres. And Delorme states that injuries to the diaphyses of long bones are always remarkable for their extent and gravity. Whether they are struck at a distance of 500 metres or 1500 metres, the damage done to a long bone by one of the new projectiles seems about the same; in both cases there are always fissures produced that are from 10–12 cm. long, the only difference being that at longer distances the splinters are more often found still adherent to the periosteum.

Capt. Smith, of England, one of the latest experimenters, states that within the 200-yard range no appreciable difference was noted between the damage done to dense and rarified portions of bone. Smith made his experiments on horses, ponies, donkeys and sheep, at first on these animals in their entirety, and afterwards on excised bones which were hung on a canvass target and fired at from varying distances up to 1000 yards. His experiments, if we were to judge by his photographic illustrations, would carry the explosive zone much further than usual, and the Lee-Metford rifle with which he experimented can certainly not be called a humane weapon.

Thus, Fig. 1 in Photo. *A* shows a bone fired at from a distance of 50 yards; the bullet struck it about the centre of its shaft, and a chasm 2 inches by 4 inches resulted, which was filled with bone-dust; the bone was broken into two pieces, and in the track were hundreds of fragments, clearly showing the shell-like effect. Fig. 2 of Photo. *A* shows practically the same effect.

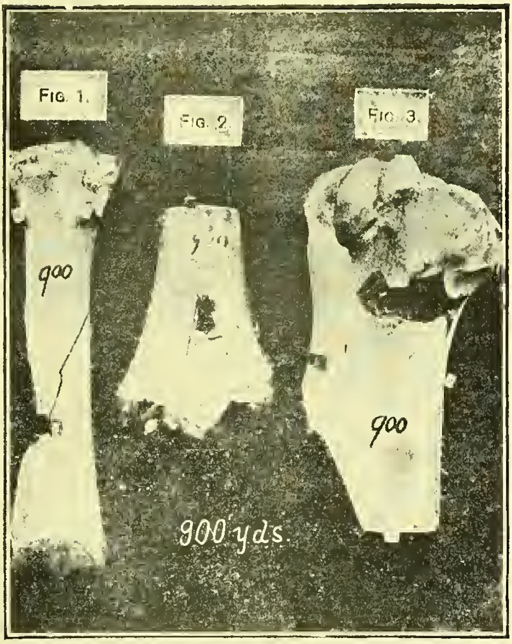


PHOTO. C.

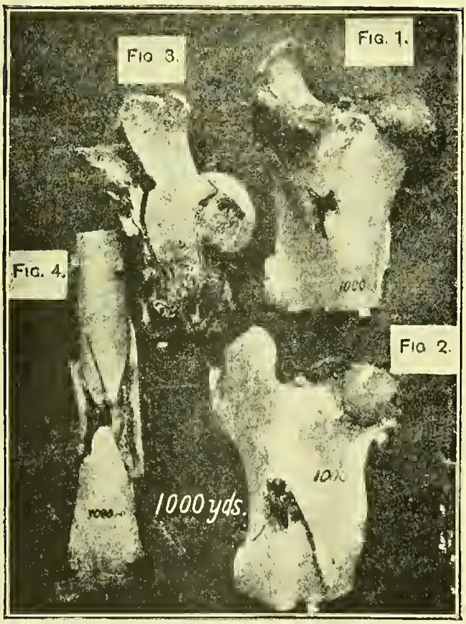


PHOTO. D.

Photo. *B*, Fig. 1, shows an arm bone which was hit at a distance of 800 yards; it was demolished with considerable loss of substance; the fracture extended down into the elbow-joint, through two or three distinct lines, and long fissures also ran up the shaft of the bone.

Even in the three figures in Photo. *C*, we still see extensive fissuring with loss of substance; and in the four figures shown in Photo. *D*, taken from specimens obtained from the 1000-yard range, we see anything but a pure and simple penetrative effect.

Smith says that when the thigh-bone of any one of his animals was struck at a distance of 50 yards in the middle of the shaft, it fell to the ground, nothing but the extremities of the bone remaining; the missing parts were thrown out at right angles to the target for a distance of six feet and a large splash of blood and marrow, eight inches in diameter, remained on the target as evidence of the shock. At a distance of 50 yards, then, Smith's results with the Lee-Metford rifle show that direct hits of bones invariably result in pulverizing, smashing and fissuring them—the resistance of the surrounding periosteum being apparently without influence on this result. Even at longer distances, simple grazes of bone may result in complete transverse fractures, or, in case the resistance is somewhat less great, extensive splintering, at least, will occur. At a distance of 1000 yards the Lee-Metford bullet may, according to Smith, cut a clean hole through a bone and leave its track filled with bone-dust, but even here his cuts show frequent fissuring and large splinters.

Captain Smith, among others, makes one suggestion which appears to be a very good one. He draws attention to the fact that in wars with savages who, as is well known, experience very little shock from gunshot wounds, especially small flesh wounds of the upper extremities, such shots would scarcely suffice to disable them, but would leave them, for a time at least, just as dangerous as they were before. One of the lessons which may be derived from the experiments with the new projectile on bones would be to aim at the lower extremities, and it certainly would appear impossible for even a savage to travel with a fractured bone in any part of the lower extremities.

For the purpose of illustrating the purely penetrative effect of the new projectile, produced anywhere between 500 and 2000 meters, we here reproduce a photograph by La Garde that shows this effect very well. (See Photo. *E.*)

Captain La Garde experimented with the "experimental" Springfield rifle which is a 0.30 caliber gun, the projectile of which has an initial velocity of 2000-foot seconds; its projectile is made of a German-silver jacket, filled with a core of lead, and is not cannelured nor lubricated; weight 220 grains. This illustration gives you a fair idea of what occurs to a long bone beyond the zone of explosive effect when it is hit with one of the new projectiles—barring, of course, exceptions.

Our army officers have, as you may know, decided in favor of the Krag-Jorgensen model.

We will conclude this discourse with a few remarks on *Bullets* and *Bacteria.* Both are enemies of human life.

Bullets are artificial products, devised by human ingenuity, and in themselves dead matter. Bacteria are the living enemies of human life, being the product of vegetable life. While, then, the two have nothing in common with each other, so far as their origin and composition is concerned, in gunshot wounds we may find both associated for one common end—the destruction of human life. It was formerly erroneously held that the bullets were sterilized, that is, made free from bacteria by the heated gases produced in the combustion of the explosive material as well as by the heat produced from friction in the passage of the projectile through the air. Moreover, the heat produced when the projectile collided with some resisting object, was also believed by some to kill the bacteria that might adhere to it or to the object struck. This idea, however, has been disproved by experiment. Thus, Dr. B. von Beck, of the fourteenth Army Corps of Germany, among other important experiments, conducted some with a view to determining the amount of heat imparted to the hard bullet of small caliber having a mouth of steel or copper. He fired into a target made of boards and thin sheets of iron arranged alternately about an inch apart. The projectiles were recovered as quickly as possible after firing, never allowing more than ten seconds to intervene between the firing and the recovery of the projectiles, which were dropped into 300 grams of mercury in a paper box 7 cm. high and 3 cm. wide. By means of a cork fixed on the bulb of a thermometer he held the projectile under the mercury and noted the rise of the temperature of the metal. He found:

PHOTO. E.

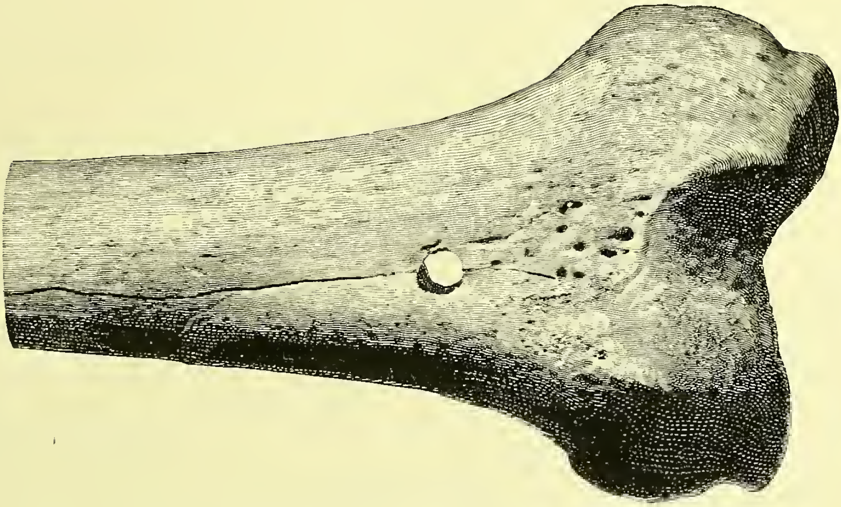


Fig. 1.—Gunshot injury of the lower third, right femur, by the .''30 caliber German silver jacketed projectile with the velocity common at 1,200 yards. The projectile perforated the anterior face of the bone about its middle, immediately above the upper margin of the articular surface making a clean-cut perforation. The fissure occurred in drying, it was not present in the recent state.

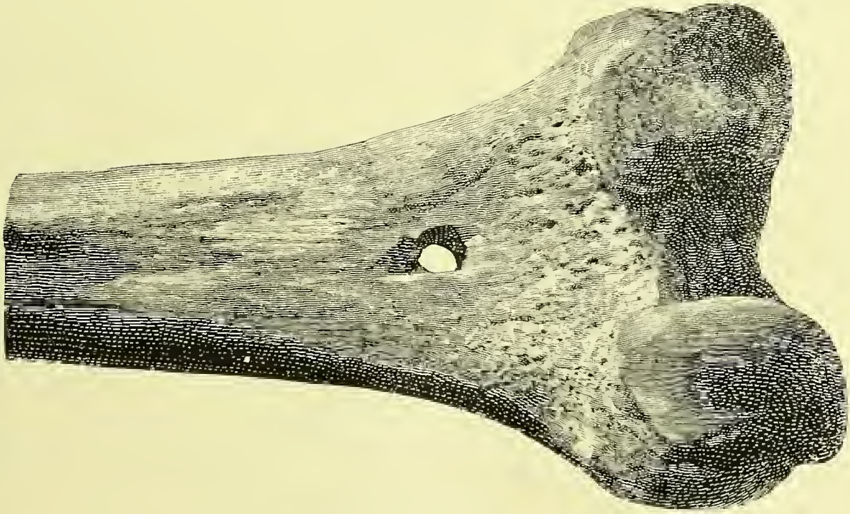


Fig. 2.—A posterior view of Fig. 1.

Temperature of the leaden bullet of .45 caliber when recovered, 69° C.

Temperature of the leaden bullet of .30 caliber covered with steel, 78° C.

Temperature of the leaden bullet of .30 caliber coverered with copper, 110° C.

When we think that the resistance offered to the projectiles in these experiments was from three to four times as great as that offered by the human body, we must agree with him when he says that the theory that certain characters of the injuries produced by the projectiles are due to heat is no longer tenable. He believes that the periphery of the projectile alone is heated because the act of heating is so instantaneous that it could not be conducted into the interior.

It has been proven experimentally, and is now beyond doubt, that neither the heat produced by the combustion of the explosive substance in the barrel, nor that caused by the friction in the air, nor even that caused by the collision of the ball against some resisting object, is sufficient to sterilize the projectile; in other words, free it from any bacteria with which it might be infected at the time.

Dr. Messner, of Wiesbaden,[1] has recently tested this question by infecting bullets with pus-forming organisms; these were fired into sterilized gelatine, and in every case infection occurred from these specific and morphologically easily recognized and distinguished microbes. Varying the experiments somewhat, he caused the bullet to pass through pieces of clothing infected with certain microbes before entering the sterilized gelatine. This also most always was found to result in the infection of the gelatine. Finally, Dr. Messner used sterilized bullets and found that even they, in passing through the air, would sometimes but not always become infected and carry infection into the wounds they made.

Captain La Garde, on examining bacteriologically the bullets in their original packages, found that 53 per cent. of them were absolutely sterile, that is, entirely free from bacteria, and that fact explains also to a certain extent why certain gunshot wounds have failed to produce infection, and why surgeons generally believed that the gases of combustion sterilized them. This sterile condition of the projectiles is believed to be owing to the cleanly methods that are used in their manufacture. In experiments with artificially sterilized bullets and guns firing into sterilized cotton, Capt. La Garde never got an infection. In all his other experiments with infected bullets, he invariably obtained an infection, not only of the sterilized gelatine, but also of certain animals which were fired into.

Although La Garde's experiments with the bacillus of tetanus proved unsuccessful in causing artificial lock-jaw, a case is reported by Habart, in which undoubted symptoms of lock-jaw were present before death, although no microscopical examination was made to verify the diagnosis.

The dangers from infection, then, in connection with gunshot wounds remain as great as ever, and antiseptic surgery will play a still more important rôle in future wars than it has heretofore. If even the dangers to life and limb have become greater, antiseptic surgery of to-day is more than a match for this increase, and we believe with the great Billroth, who says that "with clean hands and consciences the youngest military surgeons will now-a-days accomplish better results than were formerly attained by the most learned professors."

With regard to the subject of "First Aid to the Injured," Delorme says that a personal wound-package to be supplied to every soldier is still more necessary to-day than it was before; and Kipper strongly emphasizes the necessity for the instruction of every soldier in the principles of First Aid and personal hygiene. According to Habart, nothing much can be done directly in the rear of the line of fire, and the chief object is not first aid so much as the first safe transport. If the wounded can be brought under the roof of a protected tent as quickly and safely as possible, then of course, with antiseptic means, it may be possible to reduce the mortality to as low a figure as 1½ per cent., which figure has actually been attained by Mosetig, Fraenkel, Maidle and Fillenbaum in Servia and Bulgaria in 1885–6.

Haase thinks that the first dressing-station may safely be about 2400 meters behind the line of fire, instead of 4000 meters, as the order stands now. He also believes in the possibility of transporting the wounded during an action, instead of waiting until it is over. In Germany, the number of litter-bearers has been largely increased in accordance with the expected needs for an increased number of wounded in the event of a war. Every company now has four stretcher-bearers and every battery two. Including the musicians, who are also trained to do service as bearers, every army corps has 1168 bearers, and when all the twenty German army corps are in the field, leaving out reserves, its sanitary corps, under command of medical officers, numbers 45,000 men. This number seems certainly most munificent, and, if there is no projectile that can be called *humane*, the nation that provides so generously for its wounded sons and defenders as that most certainly deserves this epithet.

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4. DELORME (E.) ET CHAVASSE : "Étude comparative des effets produits par les balles du fusil Gras de 11 m. m. et du fusil Lebel de 8 m. m." *Arch. de méd. et pharm. mil.*, Par., 1891.

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